Chapter 14
Inventory Management

Overview
- Nature of Inventories
- Opposing Views of Inventories
- Fixed Order Quantity Systems
- Fixed Order Period Systems
- Other Inventory Models
- Some Realities of Inventory Planning
- Wrap-Up: What World-Class Companies Do

Definition of basic terms
- **Stock**
  - All the materials and supplies carried on hand by an organization for future use
  - Held either for sale or for use in operating/manufacturing/service processes
- **Inventory**
  - Historically, inventory referred to a list of items held in stock
  - Now, stock and inventory are used synonymously
- **Item or stock keeping unit (sku)**
  - Single type of product held in stock
  - One entry in the inventory (list)
  - Usually associated with a universal product code (UPC) or bar code
- **Unit**
  - Standard size or quantity of a stock item

Classification of Stocks
- Raw materials
- Work-in-process [WIP]
- Finished goods
- Maintenance, repair & operating supplies [MROs]
- Merchandise

Service Inventories
- Manufacturing
  - Generally some physical transformation of input materials
- Services
  - In many instances, no physical transformation of input materials takes place
  - In some services, input materials constitute an insignificant part of operating costs.
    - E.g., blank paper, forms
Output materials may be applied on customer directly
- Surgical thread, anesthetics
- Prepared food
- Proprietary cosmetics

... hence, cannot be stored by customer for use at some later time.

If service provider runs out of input materials, service cannot be performed.

Perishability ⇒ inventory problem varies tremendously in services

Cost of holding perishable items beyond a certain period is high

However, same questions and concepts apply

Major Inventory Cost Categories

- Acquisition costs
  - based on variable purchase/manufacturing cost per unit

- Ordering costs
  - Clerical time spent preparing purchase orders
  - Time spent finding suppliers & expediting orders
  - Transportation costs
  - Receiving costs (unloading, inspecting, etc.)
  - For internal order in manufacturing environment: setup costs

- Carrying (or holding) costs
  - Cost of storage space
  - Security
  - Insurance
  - Foregone interest on working capital tied up in inventory
  - Deterioration, pilferage, spoilage, obsolescence

- System control costs

Opposing Views of Inventory

- Why We Want to Hold Inventories
- Why We Do Not Want to Hold Inventories

Why We Want to Hold Inventories

- Improve customer service
- Reduce certain costs such as
  - ordering costs
  - stockout costs
  - acquisition costs
  - start-up quality costs
- Contribute to the efficient and effective operation of the production system
- **Finished Goods**
  - Essential in produce-to-stock positioning strategies
  - Necessary in level aggregate capacity plans
  - Products can be displayed to customers

- **Work-in-Process**
  - Necessary in process-focused production
  - May reduce material-handling & production costs

- **Raw Material**
  - Suppliers may produce/ship materials in batches
  - Quantity discounts and freight/handling $$ savings

**Why We Do Not Want to Hold Inventories**
- Certain costs increase such as
  - carrying costs
  - cost of customer responsiveness
  - cost of coordinating production
  - cost of diluted return on investment
  - reduced-capacity costs
  - large-lot quality cost
  - cost of production problems

*Inventory Control or Stock Control*
Consists of all the activities and procedures used to ensure that the right amount of each item is held in stock

**Basic questions of inventory control**
- What items should be stocked?

  *For each item to be stocked*
  - What inventory level should be maintained?
  - When should an order be placed?
  - How much should be ordered?

**Independent Demand Inventory Systems**
- Demand for an item carried in inventory is independent of the demand for any other item in inventory
- Finished goods inventory is an example
- Demands are estimated from forecasts and/or customer orders
Dependent Demand Inventory Systems

- Items whose demand depends on the demands for other items
- For example, the demand for raw materials and components can be calculated from the demand for finished goods
- The systems used to manage these inventories (Chapter 15) are different from those used to manage independent demand items

Independent vs. Dependent Demand

Balancing Carrying vs. Ordering Costs

Classifying Inventory Replenishment Systems

- Fixed Order Quantity Systems
  - Event triggered
  - Constant quantity ordered when inventory declines to some predetermined level
  - Requires continuous review of inventory level
- Fixed Order Period Systems
  - Time triggered
  - Order placed for variable amount after some fixed period of time
    - E.g., monthly sales call by sales representative
  - Involves periodic review of inventory level

Fixed Order Quantity Systems

- Behavior of Economic Order Quantity (EOQ) Systems
- Determining Order Quantities
- Determining Order Points
Behavior of EOQ Systems
- As demand for the inventoried item occurs, the inventory level drops
- When the inventory level drops to a critical point, the reorder point, the ordering process is triggered
- The amount ordered each time an order is placed is fixed or constant
- When the ordered quantity is received, the inventory level increases
- An application of this type system is the two-bin system
- A perpetual inventory accounting system is usually associated with this type of system

Model I: Basic EOQ
- Typical assumptions made
  - annual demand (D), carrying cost per average unit of inventory (C) and ordering cost (S) can be estimated
  - average inventory level is the fixed order quantity (Q) divided by 2 which implies
    - no safety stock
    - orders are received all at once
    - demand occurs at a uniform rate
    - no inventory when an order arrives
  - Stockout, customer responsiveness, and other costs are inconsequential
  - Acquisition cost is fixed, i.e., no quantity discounts
- Annual carrying cost = (average inventory level) x (carrying cost) = (Q/2)C
- Annual ordering cost = (average number of orders per year) x (ordering cost) = (D/Q)S

The Inventory Order Cycle

Annual Acquisition Cost
Annual demand
x Unit purchase/manufacturing cost
⇒ Not relevant

Annual Ordering Cost
Average number of orders/year
x Fixed cost/order

Annual Carrying Cost
Average on-hand inventory
x Inventory carrying cost/unit/year
Inventory Costs
- Costs associated with ordering too much (represented by carrying costs)
- Costs associated with ordering too little (represented by ordering costs)
- These costs are opposing costs, i.e., as one increases the other decreases
- The sum of the two costs is the total stocking cost (TSC)
- This cost behavior is the basis for answering the first fundamental question: how much to order
- It is known as the economic order quantity (EOQ)

Balancing Carrying vs. Ordering Costs

Total Relevant Cost:

Total Annual Stocking Cost (TSC)
TSC = Annual Ordering Cost + Annual Carrying Cost

The Basic EOQ Formula

Example
- Annual demand = 6,000 units/year
- Acquisition cost = $20/unit
- Fixed ordering cost = $200/order
- Carrying cost per unit = $5/unit/year

Calculating the EOQ

Cost Comparisons
Observations on the EOQ

■ Annual ordering cost = annual carrying cost at EOQ.
■ Total cost curve is relatively flat around EOQ
  ◆ Allows some leeway for operating limitations (e.g., supplier’s packing quantities) and inaccurate estimates of parameters.
  ◆ Without this flexibility, implementable decision systems would be very difficult to design.

Reorder Point (ROP)

\[ ROP = \bar{d} \cdot L \]

where
\[ \bar{d} = \text{average daily demand} \]
\[ L = \text{leadtime (in working days)} \]

Time Between Orders (or Order Cycle Time)

■ Order cycle time = \( Q / D \)
■ Unit of time = year, given that \( D \) is annual demand
■ May be converted to days, by multiplying by number of working days/year

Model II: EOQ for Production Lots

■ Inventory item Y is produced internally and, upon production, a unit may immediately be used for assembly into/manufacture of product X.
■ \( p = \text{rate of production of item Y per day} \)
■ \( d = \text{assembly rate of item X per day (daily ‘demand’ rate for item Y)} \)
■ Assume that \( p > d \), allowing build-up of inventory of item Y

EOQ with Usage During Production Time

Average On-Hand Inventory
Annual Ordering Cost:
same as in Basic EOQ Model
Average number of orders/year
× Fixed cost/order

Annual Carrying Cost:
different from Basic EOQ Model
Average on-hand inventory
× Inventory carrying cost/unit/year

Example: EOQ for Production Lots
■ Wash’em-All, Inc. makes washers and dryers. Plant operates 250 days/year.
■ Fabrication shop makes part # 101, at a rate of 100 units/day, at cost of $20/unit.
■ Part # 101 is used in adjacent assembly department every working day, at a rate of 40 units/day. Hence, annual demand for part # 101 is 10,000 units (40 × 250).
■ Setup cost for producing part # 101: $150.
■ Cost of carrying part # 101 in inventory: $5/unit/year.

Quantity Discounts
■ Supplier offers discount on basis of large order volume.
■ Should offer be accepted by buyer?

Model III: EOQ with Quantity Discounts
—Sample Problem
■ Annual demand for an item is 2,500 units. Cost to place an order is $5, and holding cost is 20% of the cost of the item.
■ Cost schedule for the item:
  ◆ 1 to 99 units $10.00/unit
  ◆ 100 to 199 units $ 9.80/unit
  ◆ 200 units or over $ 9.60/unit
■ What is the optimal order quantity?
Annual Acquisition Cost
Annual demand
\( x \)  Unit acquisition (purchase/manufacturing) cost
⇒ Relevant since \( ac \) changes with order quantity

Total Material Cost (TMC):
Total Annual Acquisition + Stocking Cost
TMC  =  Annual Acquisition Cost
      + Annual Ordering Cost
      + Annual Carrying Cost